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The American Standards Association is organized to provide systematic means of cooperation in establishing American Standards to the end that duplication of work and the promulgation of conflicting standards may be avoided; to serve as a clearing house for information on standardization work in the United States and foreign countries; to act as the authoritative American channel in international cooperation in standardization work

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A Standard Inch-Millimeter Conversion Factor for Industrial Use[1]

by

C. E. Johansson[2]

A discussion of the practical significance in industrial practice of the use of the standard conversion ratio 25.4

The extension of American manufacturing practice in Europe, and the establishment of branches on the Continent, where the use of the metric system is compulsory, has confronted us with the problem of having products measured in both inch and millimeter systems.

In the United States the relation between inches and millimeters, as derived from the official relation 1 meter = 39.37 inches, is 1 inch = 25.400051 millimeters.

As the value 25.400051 of the existing legal inch-millimeter conversion factor differs but slightly from the simple conversion factor 25.4, it is now proposed that the factor 25.4 be generally adopted for universal use in the American industries. This factor has indeed proved to be the most convenient, and sufficiently accurate for industrial use to meet all requirements. Realizing that although this conversion factor has been used extensively, but without a complete or general agreement, it is now proposed through the medium of the American Standards Association that the Inch-Millimeter Conversion Factor 1 inch = 25.4 mm be adopted by the industries in the United States.

When this subject was first brought before ASA, that organization immediately realized the importance of the question and a special committee was appointed which recommended the calling of a general conference for the purpose of studying and, if possible, reaching a decision on the question and submitting its recommendation for acceptance to all groups and bodies concerned.

Before an agreement can be reached, however, it is important that the question be clearly understood by all. In order fully to explain the matter, slides and data have been prepared.

Having worked a great part of my life with instruments and methods for measuring dimensions of length, I have come in contact with the problems now before us and will describe how they were met and what conclusions were reached.

Standard temperature necessary

Many years of experience in developing methods for measuring dimensions of length have conclusively proved the necessity for a temperature of definition, or standard temperature.

That a definite temperature is of great importance is evident when one considers that a variation of only one degree Centigrade will change the indicated length of a one-inch steel block .000011 inch.

Therefore, we decided on the temperature of 20 C = 68 F, and all gages manufactured by us for the American market during the years 1912-1923, and by the Ford Motor Company since 1923, have been adjusted and recommended for use at that temperature.

The expansion is proportional to the length of the piece, and as parts to be measured change in the same proportion, it was found practical when manufacturing block gages to apply a tolerance which would change in the same proportion (progressive tolerance).

When the manufacture of block gages for the American market was commenced, we requested and received from the Bureau of Standards, Washington, D. C., the information that the legal equivalent adopted by Act of Congress, July 28, 1866, was 1 meter = 39.37 inches, giving the value of the American inch as 25.400051 mm.

After some calculating and studying, we decided to use the equivalent 1 inch = 25.400000 mm as the basic ratio for the manufacture of our block gages. In manufacturing a set of master blocks, we used the ratio 25.400000 and a plus tolerance of 0.000002 inch (0.000051 mm) per inch of length, the negative

[1] Paper presented at the general conference on Inch-Millimeter Conversion for Industrial Use, held in New York on October 21, 1932, under the auspices of the American Standards Association. The conference unanimously recommended that the conversion ratio, one inch equals 25.4 millimeters, be adopted as an American Standard for use by industry.

[2] Gage manufacturer associated with the Ford Motor Company, which requested that an American Standard inch-millimeter conversion factor of 25.4 be adopted under the auspices of the American Standards Association.

tolerance being zero. We thus obtained blocks certified by the National Bureau of Standards, Washington, D. C., as representing the corresponding length based on the legal ratio 25.400051. These Master blocks have served as the basis for the manufacture of our block gages for the American market since 1912.

All block gages manufactured since 1923 by the Ford Motor Company for the American industries have been adjusted accordingly, using said equivalent 1 inch = 25.4 mm with a progressive positive tolerance, and it might be stated that over 450,000 of these gage blocks have been used by the industries in the United States without a single complaint regarding their measuring value.

The following illustrates how dimensions in inches, converted into metric measurement by using the equivalent 1 inch = 25.4 millimeter, compare with the same dimensions converted into millimeters by using the legal equivalent 1 inch = 25.400051 mm.

Among the parts of the Ford Model "A" car held to the smallest manufacturing tolerances is the piston pin.

If the diameter of the piston pin is minimum 1.0001 in. and maximum 1.0004 in., we obtain the following values when converted into the metric system:

Using equivalent 1 in.=25.4 mm	*Using equivalent 1 in.=25.400051 mm*
(*a*). 1.0001 in.=25.40254 mm	(*a*). 1.0001 in.=25.40259 mm
(*b*). 1.0004 in.=25.41016 mm	(*b*). 1.0004 in.=25.41021 mm

Difference

(*a*). .00005 mm=.000002 in.
(*b*). .00005 mm=.000002 in.

The difference between the values for 1.0001 in. is .00005 mm or .000002 in. and the difference between the values for 1.0004 in. is also .00005 mm or .000002 in.

Comparing this difference between the values as converted to metric dimensions with the allowed machining tolerance of 1.0004 in. − 1.0001 in. = .0003 in., we find that this tolerance is 150 times greater. This example being taken from the highest grade of accuracy in production work, one understands that the comparison between the difference in equivalents and the tolerances in ordinary machine work is many times greater, in that a tolerance of ± .001 in., or a total of .002 in., is 1000 times greater than the difference which is found between the equivalents.

Thus, we see that there is no danger in adopting the new equivalent from the standpoint of accuracy in machine work be it ever so close.

In order to show what a negligible difference the

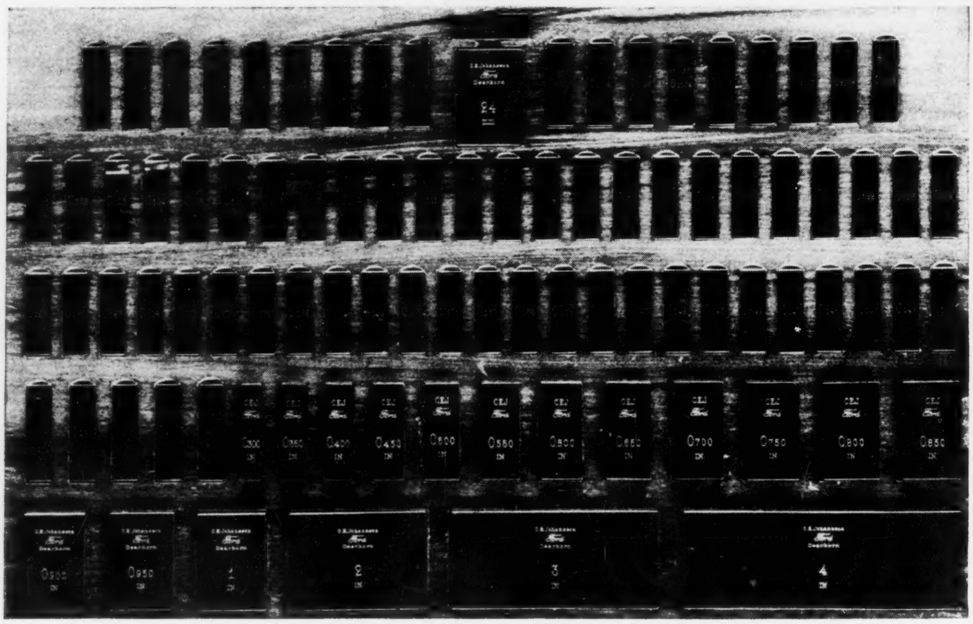


FIG. 1

A standard inch gage block set

change from the legal equivalent of 25.400051 to the proposed equivalent of 25.4 makes with the most accurate and precise machine work now performed, and of which the manufacturing of gages and measuring instruments and devices form the most important part, I will describe the tolerances to which

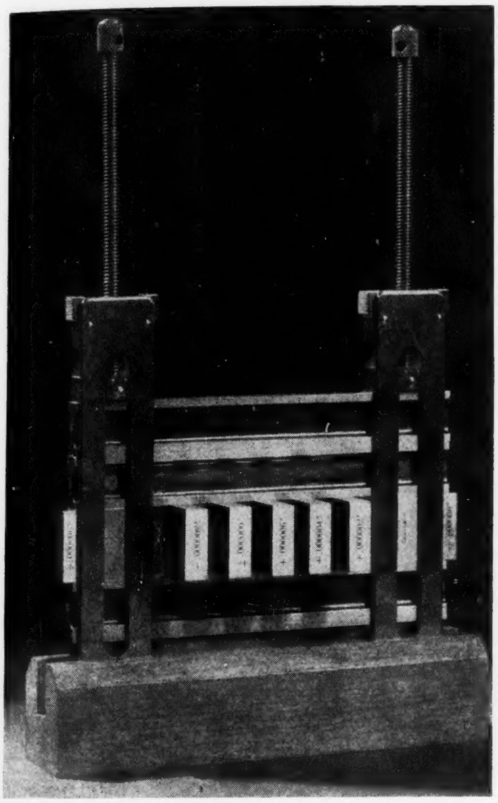


Fig. 2

Apparatus for showing effect of small dimensional variations

this work is performed and the relation between these tolerances to the difference between legal and proposed equivalent. The allowed tolerance on the most accurate of laboratory sets of block gages is ± .000002 in. per inch or a total of .000004 in. per inch and thus twice the difference between the two equivalents. Sets of block gages for less accurate work have proportionately larger tolerances wherefore the difference between the equivalents has very much less influence when considering these tolerances.

A sure and reliable way to establish true dimensions in either inch or millimeter systems, and also means for transferring dimensions from one system to the other, is obtained by using combination standard gage block sets for inches and for millimeters.

The set in inches, illustrated in Figure 1, consists of 90 blocks divided into five series, and by combining two or more blocks one obtains measuring values in steps of .00001 in. This set also contains two extra blocks in sizes 24 mm and 1.40 mm which, when combined, gives a block combination of the size of 25.40 mm equal to the inch-millimeter factor in question.

The set in millimeters consists of 114 blocks divided into five series and, likewise, by combining these blocks, measuring values are built up in steps of .00025 mm. This set also contains one extra block in size 1 inch equal to 25.4 mm or the inch-millimeter factor.

In this connection it may be pointed out that when measuring with block gages in so small steps as .00001 in. a difference in the temperature in which the measuring is done has far greater influence than the difference in equivalent.

The change in temperature of 1 C will change the length of a one-inch steel gage about .000011 inch. Comparing this with the positive tolerance for quality AA gage blocks, which tolerance is the same as the difference between the legal and proposed equivalent, we find that the change in the length of the gage caused by the change in temperature is more than five times greater than the difference between the equivalents.

To show in a practical way the difference between the equivalent 25.400051 and 25.4, a series of blocks have been made up, as illustrated in Figure 2. The blocks have the following sizes: 3 blocks of 1.000006 in., 1 each of 1.000004 in., 1.000002 in., 1.000000 in., and 0.999998 in. If one block of size 1.000006 in. is placed at each end between two parallels, so that a frame is formed, then the space between the two parallels will be 1.000006 in. If now the third block 1.000006 in. is inserted in this space, it will be found that it fits so that a certain pressure is required to move or turn it. Inserting block 1.000004 in., we find that this block so nearly fills the space that the difference between the fits of this block and the former can be detected only by a sensitive touch of the hand. The difference between these two blocks is equal to the difference between the two equivalents.

Inserting the remaining blocks having a difference of .000004 in., .000006 in. and .000008 in., respectively, we find that they are easier to move and turn in proportion to the clearance or play between them and the parallels.

Now it might be said that the equivalent 25.4 is acceptable for use with smaller lengths in the manufacture of machine parts, but how about larger lengths?

A rapid calculation will show the following:

1 foot = 12 inches	Difference = .000024 in.
1 yard = 36 inches	" = .000072 in.
1 mile = 63,360 inches	" = .126 in. or about 1/8 in.

Conclusion

Without mentioning all factors in favor of adopting the equivalent 25.4, I will point out what I think is the most deciding point; namely, to accomplish a much desired complete unification in the matter of converting measurement of length from the inch to the metric system or vice versa. The step that we have to take is small in comparison with the steps England and France have taken for the same purpose.

England has, as is now known since 1930, adopted the conversion equivalent 1 inch = 25.4 mm as being sufficiently accurate for translating linear dimensions quoted in British Standard Specifications into metric measure. The legal British equivalent being 1 inch = 25.39998, the step taken is .00002 mm = .0000008 in., but it must be remembered that the British Standards Institution in this connection also has taken the step to adopt 68 F as the standard reference temperature for industrial gages of length instead of 62 F, which was used up to 1930. This will, therefore, change the length of the English industrial one-inch steel gages about .000037 in. taking the linear expansion for steel equal to .0000061 in. per inch and per degree Fahrenheit (= .000011 in. per inch and degree Centigrade).

France has also adopted the temperature of 20 C (68 F) as standard reference temperature for industrial gages of length. France previously having used the temperature of 0 C has, therefore, been obliged to change the industrial gages for length even more than England, or .000220 in. per inch.

Now, taking into consideration the remarkable spirit of conciliation shown by the other industrial nations, I strongly urge that for the sake of universal unification we now unanimously recommend that the equivalent 1 inch = 25.4 mm be officially adopted for use by the industries in the United States, and that it be made as a basis for conversion tables to be published. A decision in this line is much looked for by all countries using the metric system and I believe that they are all ready to adopt and use this conversion factor.

Concrete Building Units

A revision of the Simplified Practice Recommendation on concrete building units, R32-32, has been accepted by industry under the procedure of the Division of Simplified Practice of the National Bureau of Standards. It became effective on December 15, 1932.

In the revision the length dimension for three items has been changed from the nominal dimension of 12 inches to the actual dimension of 11¾ inches; the maximum permissible variation, over and under the given dimensions, was placed at ¼ inch for block and tile; and the tolerances of concrete brick have been changed to 1/16 inch in height, ⅛ inch in width, and ¼ inch in length. These tolerances, which have been adopted for concrete brick in the Simplified Practice Recommendation, are the same as the tolerances prescribed by the American Society for Testing Materials in connection with clay and sand lime brick masonry units.

Simplified Practice Recommendation on Vitrified Paving Brick

A revision of Simplified Practice Recommendation 1-32 covering vitrified paving brick, which will include the 4 x 3 x 8½ inch vertical fiber lug brick and eliminate the 3½ x 4 x 8½ vertical fiber lugless brick, has received the required degree of acceptance by all interests in the industry, under the procedure of the Division of Simplified Practice of the National Bureau of Standards, and will be effective from December 1, 1932. With these changes the new list of six recognized stock varieties will cover 75.9 per cent of the total shipments as compared with 56.1 per cent for the previous list, since the size eliminated averaged less than 3 per cent of the shipments of vitrified paving brick during the past four years, while the size added represents 22.6 per cent of the shipments for 1931.

Federal Specifications on Household Textiles Available

The following Federal Specifications relating to household textiles were published recently and may be purchased at five cents per copy from the Government Printing Office, Washington, D. C., or may be purchased or borrowed through the office of the American Standards Association: plain roller gauze bandages; crinkle bedspreads; cotton handkerchief cloth; cotton plied-yarns (army, numbered, and tent-duck) duck; plain gauze; cotton handkerchiefs; bleached jean; unbleached-bobbinet mosquito netting; white table oilcloth; wide unbleached cotton sheeting; cotton, and cotton and linen-mixed crash towels.

Developments in National Standardization During the Year 1932[1]

by

Cloyd M. Chapman,[2] *Chairman*
ASA Standards Council

Important new standards and projects; wide distribution of standards; value of ASA cooperative methods

The year 1932 has tested the mettle of companies and of organizations. Many have been subjected to challenges as to the rightness of their product and work; and nearly all have had to devise the means of doing as much or more with a smaller amount of working capital. Those that have measured up best under the test are those whose products or services have been found essential and in some instances even more useful during a time of stress.

In reviewing the accomplishments of the American Standards Association during the last eleven months, the facts give many reasons for reassurance that the purposes and functions for which the organization was set up were sound and that the services of ASA are needed more today than ever before. Evidence of this is found not only in the increased number of new projects submitted for development but also in the importance of certain of the new projects to the fundamentals of industrial activity. Among the new projects submitted are two that illustrate this point.

In October, a conference was held in New York to consider the advisability of adopting the ratio of one inch equals 25.4 millimeters as the standard conversion factor between the inch and the millimeter for industrial use. This recommendation was submitted to ASA by the Ford Motor Company. Here is a subject that for more than a generation has been tinged with the animus of strong personal feelings both pro and con and about which it was nearly impossible to hold any group discussions free from emotional bias. However, when the subject was lined up in a clear-cut fashion and a conference called under ASA procedure it was proved possible for the subject to be viewed calmly in the light of its merits and for those present to arrive at unanimous agreement to submit the recommendation to industry for approval as American Standard practice. Those who are familiar with the earlier discussions of the same subject will realize what a genuine accomplishment it was to secure a unanimous recommendation from such a conference. It is doubtful if any organization other than ASA could have secured an agreement that would have been acceptable to all the groups concerned.

The second project of outstanding importance is a request received from the National Bureau of Casualty and Surety Underwriters that standard specifications for tests for non-shatterable glass be developed. It is suggested that test and performance specifications be sufficiently rigid to assure all those interested in the use of non-shatterable glass that any glass meeting the standard requirements could be assumed to properly deserve the name of safety glass.

During the past eleven months, ASA has approved 43 standards, of which six were revisions, four were advances from American Tentative Standards to American Standards and 33 were entirely new projects. Six of these were electrical projects, and eleven of them pertained to petroleum products and lubricants, many of which will be of great practical use in purchase specifications and tests.

In addition to the new projects on non-shatterable glass and the inch-millimeter conversion factor, other recommendations have been submitted covering acoustical measurements and terminology, a group covering standards for the motion picture industry including sound pictures; another for the development of a city gas code; and one on shellac, synthetic resin and other similar insulating materials; one for a standard method of rounding numerical values; and one for working compressed air. In all, 32 new projects have been submitted since January of this year.

The distribution and sale of approved standards have continued remarkably well considering the re-

[1] Report presented at the Annual Meeting of the American Standards Association, Hotel Astor, New York, Wednesday, November 30, 1932.

[2] Consulting Engineer, United Engineers and Constructors, Inc., New York; representing the American Society of Mechanical Engineers on the ASA Standards Council.

tarded business conditions. Even after the 25,000 distribution of the wood pole standards which was reported last year, nearly 5,000 more copies of the specifications were sold this year. Excellent distribution has been made of the Safety Code for the Protection of Industrial Workers in Foundries. Every member of the two foundry associations received a copy of this code, and through the cooperation of the National Safety Council orders were received from non-member foundries, making a total of about 5,000 copies that have been sold. About 800 copies of the three recently approved wire and cable standards were sold to producers and users. The report on certification and labeling activities in the United States which appeared in the January issue of INDUSTRIAL STANDARDIZATION[3] (formerly the ASA BULLETIN) was widely distributed and in many instances was reprinted in whole or in part by other organizations.

Experience during the year has indicated that many of the standards approved by ASA can be used to advantage by producers and distributors as effective sales promotion material, but to do this, copies must be made available to them at a reasonable price in quantities. Cooperative arrangements that have been exceedingly helpful in this respect have been made with a number of sponsors who publish American Standards. As this program is developed for promoting a wider use of American Standards by various industries, it will undoubtedly be possible to make further quantity purchase arrangements that will help to put standards in the hands of those who can best use them and profit thereby. It becomes more and more obvious that little good is accomplished if standards are merely approved and then everyone calmly sits back assuming that the job is done. The job is *not* done until the standards are well known and generally used. Unless this is the case, they might as well not be in existence. The problem of ASA in this respect is not unlike that of the manufacturer. He may make the best mouse-trap in the world, but the world will not beat a track to his door to buy unless he lets the world know that he makes a superior product and, further, makes his prospects feel a need for what he offers. Through its monthly publication, through abstracts of reports on new developments prepared for the press, and through special promotion compaigns on individual standards ASA has made real progress in promoting the use of its standards. With a smaller number of abstracts released, the amount of space used by the technical press in the discussion of ASA activities has perceptibly increased. This has occurred in spite of cutting down the mailing list to the technical press. During the year much less money was spent on promoting the sale of standards, only one price list was issued, and no year book. This diminution of activity has been reflected in results, and merely gives another proof that in a movement such as that of ASA, results come in direct proportion to the efforts and energies expended in a given direction. "Keeping everlastingly at it" applies just as well to the introduction of standards into practice as to the sale of automobiles, telephone service, or toothpaste.

One of the major developments of the year has been the active functioning of the Electrical Standards Committee. The number of electrical projects approved in 1932 is by no means a gauge of what the ESC has been doing. Under the new alignment many of the jurisdictional difficulties that had been so troublesome and caused so much delay in the past are being eliminated, and action is replacing inaction. The results obtained by the electrical group suggest that a similar reorganization of the other advisory committees would prove equally as helpful.

In these days of economic stress, it is particularly important that there be organized cooperation among the industrial groups to prevent the wasteful expense resulting from conflicting standards set up by isolated groups acting alone, and solely in their own interest. In many fields the day has passed when a producer group can set up standards for its own products. Strong consumer groups not only demand but are in a position to enforce acceptance of their ideas, or at least to take an important part in setting up standards for products which they buy and use. This has long been true of the large manufacturing units that are large buyers of intermediary goods and is becoming increasingly common among smaller companies. In the American Standards Association, industry has available a tried and proven method for organized cooperation, sufficiently flexible to meet its needs; and these methods for the development of standards have obviated the need for formulating a plan of cooperation for each individual problem as it arises. Instead of many organizations handling such problems and the inevitable duplication of energy that this would entail, there is the one recognized clearing house that is experienced in its work and that operates at unusually small expense. What ASA saves industry in its safety code program alone is worth many times its annual budget.

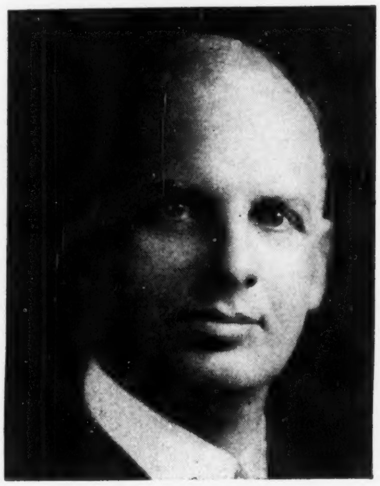
It has been necessary for ASA to materially reduce its budget during the past year in keeping with the spirit of the times, yet its constructive work has been kept going. Industry is continuing to provide funds to carry its program forward, realizing that it

[3] Vol. 3, No. 1, p. 1.

is far more satisfactory for industry to set up its own standards than to have them imposed from some outside agency. The year just passed has shown increased cooperation in many directions, which in turn has increased the confidence of industry in the American Standards Association method of cooperation. In the molding of public relations policies, ASA has established itself as a constructive force that can assist industry in emerging from the present period of depression.

Howard Coonley New President of ASA; F. E. Moskovics Vice-President

Howard Coonley, president of the Walworth Company, has been elected president of the American Standards Association, and F. E. Moskovics, chairman of the Board of Directors of the Marmon-Herrington Company, vice-president for the year 1933. Both Mr. Coonley and Mr. Moskovics are members of the ASA Board of Directors, Mr. Coonley's membership dating from 1928 when he was appointed to represent the American Society of Mechanical Engineers, and Mr. Moskovics' membership from February, 1929, when he became the representative of the Society of Automotive Engineers.



Howard Coonley

Mr. Coonley began his business career with Walter Baker and Company in 1900. In 1902 he became vice-president of the Coonley Manufacturing Company, becoming president of the concern in 1908. He has been the president of the Walworth Company, manufacturers of steam, gas, and water users' supplies since 1913. He is the director of several industrial, insurance, and banking organizations. During the war he was vice-president of the United States Shipping Board Emergency Fleet Corporation. In 1925 he was appointed chief of the First Chemical Warfare Procurement District. He is also chairman of the Governor's Committee on Street and Highway Safety of Massachusetts, a member of the Advisory Committee of the Graduate School of Business Administration, Harvard University, and a trustee of Boston University.

Mr. Moskovics has devoted almost his entire engineering and business career to the automobile industry, entering the field first in Europe with Daimler, following studies at the Armour Institute of Technology in Chicago, and also in Europe. Later, in this country, he was with the Continental Tire Company and was a partner in the firm of Brandenburg Brothers, designing, manufacturing, and selling automobile parts. In 1907 he became general manager of the Kingston Motor Car Company,

F. E. Moskovics

and in that year he designed his first automobile, the Allen-Kingston. He was later connected with the Remy Electric Company of Anderson, Indiana, as sales manager, and with the Nordyke and Marmon Company of Indianapolis for a time as commercial manager and later as vice-president. In 1924 he assumed the vice-presidency of the Franklin Automobile Company, and in 1925 he became president of the Stutz Motor Car Company. In 1929 he resigned to assume the presidency of the Improved Products Corporation, an investment banking institution. In addition to being chairman of the Board of the Marmon-Herrington Company, he is vice-president of the Frederick H. Levy Company of New York.

Chapman and Irwin Elected Officers of Standards Council

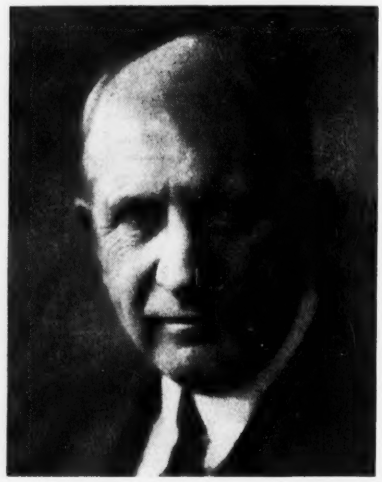
Cloyd M. Chapman, consulting engineer, United Engineers and Constructors, Inc., New York, was re-elected chairman of the ASA Standards Council, and J. C. Irwin, valuation engineer, Boston and Albany Railroad, Boston, was elected vice-chairman at the annual meeting of the Standards Council on November 30.

Mr. Chapman was the first vice-president elected

James C. Irwin

by the American Standards Association following the re-organization of the American Engineering Standards Committee and the formation of the American Standards Association in October, 1928. He was elected vice-chairman of the ASA Standards Council in December, 1930, and was re-elected in December, 1931. He is a member of the Mechanical Standards Advisory Council, and is chairman of the Sectional Committee on Standardization of Shafting (B17), representing the American Society of Mechanical Engineers on the committee.

Mr. Irwin has been a member of the ASA Stand-



Lucas-Kanarian, Photographers

Cloyd M. Chapman

ards Council representing the American Railway Association—Engineering Division since June, 1930.

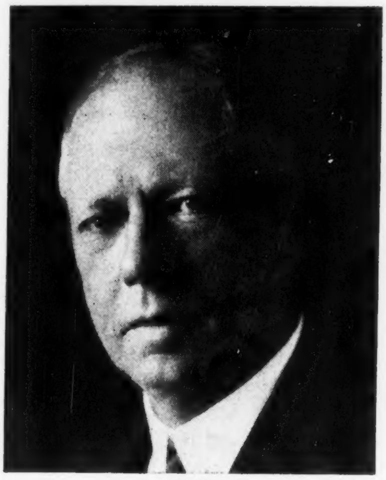
He was graduated from the University of Pennsylvania as Civil Engineer in 1890. After two years of post-graduate work and as instructor in civil engineering, Mr. Irwin entered the service of the New York Central Railroad and has been employed by the New York Central and subsidiary lines continuously since that time. He has worked on construction of the block signal system, and as trainmaster, superintendent of signals on the Mohawk Division, superintendent of the Hudson River Bridge Company at Albany, division engineer of maintenance and construction of the Mohawk and Adirondack Division, general assistant to the chief engineer, assistant to the general superintendent, superintendent of construction on electrification in the New York Suburban Zone; resident engineer on construction of the Grand Central Terminal, chief engineer of the Rutland Railroad, and valuation engineer of the Boston and Albany Railroad. He is a member of the American Railway Guild, a life member of the American Society of Civil Engineers, a member of the New York Railroad Club, and a member of the Executive Committee of the New England Railroad Club.

Mr. Irwin is also a director of the American Railway Engineering Association, chairman of the Com-

mittee on Outline of Work of the A.R.E.A. Board of Directors, and chairman of the A.R.E.A. Committee on Standardization.

Retiring President of ASA Urges Continued Effort

The work and accomplishments of the American Standards Association in the four years since it succeeded the American Engineering Standards Committee were reviewed by Bancroft Gherardi in his address as retiring president of ASA at the annual joint meeting of the ASA Board of Directors and Standards Council on November 30. Mr. Gherardi discussed the position of the American Standards



Kaiden-Keystone Photos

Bancroft Gherardi

Association in industry and urged the continued support of the organization.

He also commented on the value of the new administrative set-up of the Association under which the work of the Association has progressed more smoothly each year since the re-organization.

"In the last analysis," Mr. Gherardi pointed out, "the success of the industrial standardization movement as headed up by ASA is dependent upon the work of the Standards Council, which is responsible for the organization, follow-up, and completion of specific standardization projects, together with the development of the techniques for carrying on national standardization work."

Mr. Gherardi, who is the vice-president and chief engineer of the American Telephone and Telegraph Company, was elected to the presidency of the American Standards Association in December, 1930, and was re-elected the following year. Before taking up this office he had been an active member of the ASA Board of Directors since the organization of the Board in the latter part of 1928. He was also for a time the chairman of the Finance Committee.

Resolution on Death of Dr. Burgess

The following resolution was adopted by unanimous rising vote at the annual meeting of the Board of Directors and Standards Council on November 30:

RESOLVED—That through the death of our colleague, Dr. George Kimball Burgess, the American Standards Association has suffered the loss of a wise, experienced, and beloved counsellor, one whose accomplishments in standardization assisted materially in furthering the objects of the Association, and who served consecutively for thirteen years as member of the Standards Council and the Board of Directors.

RESOLVED—That this resolution be spread upon the minutes, and that copies be transmitted to Dr. Burgess' family and to the Secretary of Commerce.

Stevenson Represents ASA on Planning Committee

A. A. Stevenson, Ardmore, Pa., was re-appointed by the ASA Board of Directors at its meeting on November 30 to represent the American Standards Association on the Planning Committee of the Division of Simplified Practice of the National Bureau of Standards.

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Technique of Size Control in Precision Grinding Operations[1]

by

R. E. W. Harrison[2]

A survey of factors of operation control and design affecting the accuracy of grinding machine operations; methods of accuracy control

This is the second and concluding section of Mr. Harrison's paper. The first section was published in the issue of December, 1932.

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Design

Influence of grinding machine design on precision

Accurate size control in precision grinding operations is dependent on a multitude of conditions, all of which must start right, and be kept right, if the proper result is to be achieved, *i.e.,* accurate production at low cost.

Initial accuracy—By this is meant the initial accuracy of the grinding machine as a machine tool. Basically we are concerned with true plane surfaces and consistent axes of rotation. These are simple elemental details, but on them depend the ability of the machine to produce the desired results. It is axiomatic that the deviation from the true axis or the true plane of motion in a precision machine cannot exceed the limits of accuracy in the work which it is expected to produce on the machine.

When building precision grinding machines, therefore, every machine must be made the subject of a very rigid inspection test, both running light and under load, and the results recorded on a test sheet for future reference. It is obviously illogical to expect a machine produced to limits of accuracy of .0005 in. to produce work to an accuracy of two or three tenths of a thousandth, but strange as it may seem, such demands are sometimes made on machine tools. Experience indicates that only supervision which is trained, and machinists, inspectors, and erectors, also, who have been trained to work in the finer brackets of accuracy, are capable of producing machines which will produce accurate work to start with, and which will retain this accuracy over a period of years.

A great deal more might be said about the manufacture of grinding machines; however, the problem in the last analysis is basic, inasmuch as it goes right back to the engineering design.

The design of a modern precision grinding machine capable of producing accurate work consistently in the minimum of time, and over a period of years, calls for a knowledge of the characteristics of materials far in excess of that which is demanded in the manufacture of any other type of tool. While in many cases the stresses are light, the speeds are invariably high, and vibration, the arch enemy of successful results, is an ever present danger.

The successful design is that which, while accomplishing its purpose, will continue to so act throughout its useful economic life, and this calls for a detailed knowledge of potential sources of wear, and the building into the design of such features as will insure that this unavoidable wear has the minimum effect on the accuracy-producing capacity of the machine.

Resistance to distortion—During recent years the increase in horsepower applied to grinding wheels has provided many new problems for the designer of the grinding machine, as stresses and strains are involved now which, even five years ago, were undreamt of. It is not unusual for motors of 60 hp. to be applied to grinding wheel spindles, and even those motors are quite frequently overloaded. It will be realized by all those called on to deal with design problems involving such horsepowers that a knowledge of the strength of materials and the possible effects of distortion is required. Here again, considerable thought and imagination are necessary to insure that, when distortion takes place—and it is inevitable that such distortion will take place—its effects are minimized, and rather than resulting in the spoiling of the work which is being operated upon, it will exert its influence in the other direction. In

[1] Paper presented before the National Machine Shop Practice Meeting of the American Society of Mechanical Engineers in Buffalo, October 3, 1932.

[2] Secretary, Machine Shop Practice Division, American Society of Mechanical Engineers; member of the Sectional Committee on Allowances and Tolerances for Cylindrical Parts and Limit Gages (B4), under ASA procedure.

other words, rather than have the grinding wheel dig into the work and make it undersize, it is far better to have it spring away from the work and leave the work oversize.

With the increased use of the high-production infeed type centerless grinding machine, wherein the cut is not permitted to die out, and the piece of work is submitted to grinding action for a prescribed period of time, it is absolutely necessary that distortion in the machine elements be kept down to a minimum and that, if and when it does take place, its effects will be to leave the work large rather than small.

Natural frequency—With a grinding wheel weighing several hundred pounds, and up to 36 in. in diameter, revolving with a peripheral speed of from 6,500 to 7,000 ft. per minute, and with work rotating up to 120 ft. per minute, the problem of natural frequency of vibration is a very real one; especially where, as is sometimes the case, these frequencies develop into harmonics and they in turn manifest themselves as chatter marks on the work.

The wise designer is always on the lookout for possible harmonic combinations and tries to so arrange his components that their frequencies are not liable to synchronize, the general tendency, of course, being to make everything very heavy.

While this is commendable, it is not necessarily the answer to the question. Considerable judgment is required in regard to the proper distribution of metal in any modern precision grinding machine.

The biggest bugbear which has still to be overcome in grinding-machine operations is the provision of adequate dynamic balancing facilities for the high-speed rotating members. Ultimately it is to be expected that an automatic dynamic balancing of the grinding-wheel spindle assembly will be possible, but until this mechanism is made available, it will always be necessary for the operator to watch the grinding-wheel action and, whenever necessary, arrange the balancing slugs in such a way that vibration due to unbalance is kept at a minimum.

Backlash—Backlash and all its attendant evils is responsible for many of the difficulties in securing accurate size control. Modern designs recognize that backlash is inevitable, and therefore mechanisms are so arranged that backlash is kept in one direction; *i.e.,* by the provision of spring pullbacks, balance weights, preloaded bearings, pressure lubrication, etc., driving mechanisms are so arranged that with the backlash pulled in the reverse direction—with and added to the grinding load rather than subtracted from it—it can exercise the least ill effect.

With the fine limits of accuracy to which component parts are now produced, the thickness of oil film at various temperatures has become a very real problem and has led to some ingenious developments in the way of preloading, all designed with the idea of cutting out the effect of the variable film thickness of the lubricating oil.

The magnitude of the problem will be realized when it is known that the film between the spindle and bearings of many modern precision grinding machines is often in excess of the total tolerance on the work being produced. In other words, it is necessary for the spindle to float axially true in the middle of the oil film to insure that proper size control be maintained.

Temperature distribution—Temperature distribution in the machine becomes of increasing importance, as the limits or tolerances on the work become finer. Temperature change is a disconcerting variable which can cause endless trouble and its effects should be so directed and controlled that they exercise the minimum effect on the finished work.

It is because of this factor that we have to use a copious supply of coolant in all high-production grinding operations, but it should be borne in mind that, while the coolant will transfer the heat from the work to the coolant, it passes from there into the body of the machine or the coolant tank, and must be so controlled from this point onward that its effects are not felt in the alignment of the machine.

The coefficients of expansion of practically all the materials used in machine-tool construction vary considerably and difficulties have been experienced in the past caused by the contraction of bearings onto spindles, the warping of important slides, distortions set up by inadequate clearances, etc., all of which evils can be readily translated into dollars and cents and charged against that greatly accommodating shock absorber "experience."

Method of attacking the work—While not obvious at first sight, this is basic and again goes back to the design of the machine, inasmuch as there is a responsibility on the designer to provide facilities on the machine for the operator to attack the work in such a way that distortions in the machine, distortions in the work, and deviations from the true plane, due to stresses set up by the cutting action, will exercise a minimum effect from the point of view of accuracy control.

It was consideration of these factors which resulted in the universal acceptance of the economic worth and the popularity of the vertical spindle-type surface grinding machine and the conventional type of boring mill and vertical lathe.

The known tendency of a grinding wheel on a

precision grinding machine to ride the work has added indirectly to the success of the centerless method of grinding, just as the free cutting qualities involving a reduction in contact pressure between the wheel and work of the cup-wheel method of surface grinding has rightly added to the economic attractiveness of this method of removing metal.

Adjustments to compensate for unavoidable wear—While it will be readily admitted by all designers and users that a certain amount of wear is unavoidable, there is a united opinion in favor of the arrangement of the wearing elements in such a way that change in size and shape will not affect the final accuracy-producing qualities of the machine. For instance, it is frequently advisable to make spindle bearings of similar size when, according to the load-carrying duties, one of the bearings could be made smaller. However, a nice balancing of the merits of the case indicates that it is better to make both bearings the same size and secure greater uniformity in wear, which will automatically take care of alignment.

The same considerations are applicable to the design of spline shafts, inasmuch as two shafts designed to carry components which operate in conjunction with each other, and which must be kept in true axial or plane alignment, should be so proportioned that the unavoidable wear which will take place will be uniform in both cases and the relative alignment will not be materially disturbed.

A nice balancing of the merits of relative schemes for supporting spindles and spindles and cutter heads quite frequently indicates that it is better business to sacrifice some small convenience of operation or item of appearance to secure that uniformity of wearing surfaces which will preserve the basic accuracy of the machine over the maximum length of time.

Where it is found necessary to provide means for compensation for unavoidable wear, care should be taken by the designer to insure that when such adjustments are made they contribute to, rather than detract from, the basic accuracy of the machine.

Aging of units affecting alignments—Nothing is quite so disconcerting to both the engineer and the production superintendent as to have to contend with the effects of working due to aging in machine components. This is a variable which increases in importance as the tolerance on the finished work diminishes. The almost unbelievable care which is taken by the manufacturers of plug gages, and particularly gage blocks of the Johansson or Hoke type, is ample evidence of the importance which must be attached to this particular problem in the securing of permanent accuracy.

It is true that in some cases the effects of aging can be obtained in an accelerated way by hammering, tumbling, normalizing, and seasoning in the open air, and while many short cuts have been devised, the fact remains that every experienced engineer and mechanic knows that no matter what the design may be, castings will invariably change shape, and this change in shape must be compensated for by an adjustment built into the foundation of the machine itself.

Particularly is this the case in those machine tools where the beds are long in proportion to their width and height, and the machine which lacks the facilities for correction of alignment due to aging will, in course of time, only be capable of producing work within the wider tolerances.

Fundamental principles of applied mechanics—While it is sometimes possible to transgress the laws of applied mechanics in the design of machine tools used for the production of work to what is termed commercial limits of accuracy, no such divergence from theoretically correct practice can be tolerated in the design of a precision grinding machine. Although it is absolutely true that the stresses in action are often quite small, consistency in accurate sizing within close tolerances can only be obtained when all the mechanical elements are adequately proportioned, well made, and strictly in accordance, in so far as design is concerned, with the accepted principles of applied mechanics.

Such anomalies as over drives, disproportionate cantilevers, badly distributed loads, and negligence of the effect of lack of dynamic balance are all fundamental and an offense against any one of them is sufficient to jeopardize the performance of the whole machine.

While it may seem strange that the fundamental principles of applied mechanics should be mentioned in an article of this kind, the explanation is, that many years of experience and contact with a great variety of designers has indicated to the writer that practically all of the really serious errors which are made in machine tool design come under this heading.

The effect of the elasticity of lubricating oil—In the endeavor to produce work with a variation from the nominal size not in excess of two ten-thousandths of an inch with a cutting tool carried on a spindle, this spindle having at least five ten-thousandths of clearance between its outer diameter and the supporting bearing, many special problems are encountered. In the first place, the spindle is floated on an oil film which in itself is quite elastic, even though the load-carrying capacity of the oil film

under certain conditions may be exceedingly high. However, this oil film varies in its load-carrying capacity partly according to its viscosity, and its viscosity in turn is controlled by temperature, and the temperature in turn is controlled by the highly variable factor of the grinding load.

In view of the fact, therefore, that the oil film with its elastic properties is the most variable and sensitive element in the train of load-carrying and transmitting members, it is essential that every effort be made in the operation of the precision grinding machine to insure that the load applied to the oil film be kept as consistent, both as regards intensity and periodicity, as possible. This entails very careful attention to the dynamic balance of the grinding wheel and spindle assembly, the roundness of the spindle, the adequacy of the bearing areas and the consistency with which the oil is fed to the spindle, and the adequacy of design in the carrying channels to insure that this flood of oil is easily distributed along the whole of the bearing areas.

So much for the cutting element. The same conditions apply precisely to the work-rotating and supporting elements. As in these, we have to contend with lubricated surfaces and a number of joints, all of which presumably carry their quota of oil film. While this, of course, is not an insurmountable difficulty, it serves to indicate the hazards imposed by lack of attention to small details when operating machine tools designed to produce work to very small tolerances.

Referring back now to the diagram (Figure 5)[3] in which is made a graphical presentation of the number of passes, the stock reduction, and the gradually increasing accuracy of the piece, it will be readily understood how the precision of a hopper feed to a through-feed centerless grinding machine will materially improve the accuracy of the product, inasmuch as by feeding wrist pins continuously between the grinding and regulating wheels, the pressure tending to open the throat of the machine is maintained at a constant figure, the variation in this pressure being directly proportional to the extent of the tolerance on nominal size permissible in each pass.

Cumulative errors must not exceed prescribed tolerances—The virtues of a design which so arranges the elements that the forces generated in removing metal tend to close rather than open all joints, and also tends to drive the spindles into their supporting bearings rather than to lift them against the relatively weakly supported cap, will be apparent. Furthermore, consideration of the points mentioned in the foregoing paragraph will serve to emphasize the necessity for curbing the minute errors of alignment and pitch, so that their accumulated effect may not exceed, under any circumstances, the prescribed tolerance on the work.

[3] See p. 304, December, 1932.

Location of the machine in the production line—The foregoing brief summary of the factors in the machine affecting the technique of accurate size control would not be complete without reference to the

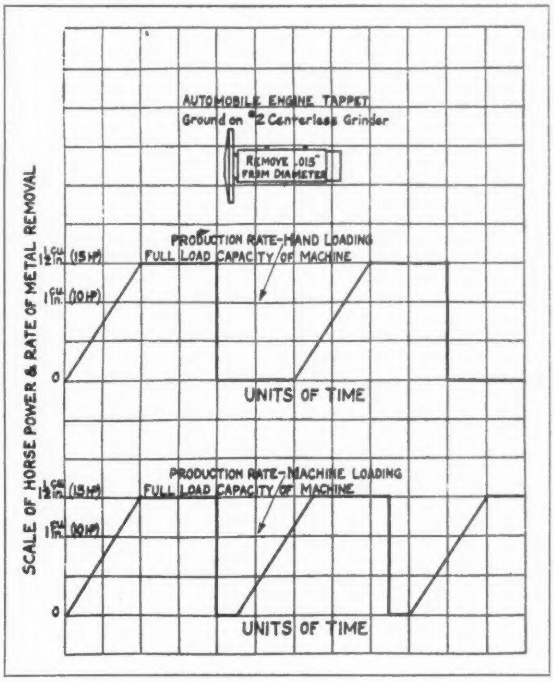

FIG. 6

Production rates for hand and machine loading

fact that the location of the machine is a matter of major importance, inasmuch as the finest precision grinding machine produced will, on occasion, perform erratically if subjected to adverse outside influences due to a faulty location.

An accurate sizing mechanism composed of such elements as cast iron, steel, and lubricating oil is very sensitive to outside influences, and for this reason the selection of the site for a precision grinding machine should be given just as careful consideration as the actual design of the machine itself.

The most commonly encountered outside influence adversely affecting the performance of the tool is vibration, and for this reason care should be taken to locate the machine in such a way that vibrations from other machinery are not transmitted to it. Likewise, the location should be selected after due consideration to temperature changes and freedom from dirt.

Effect of design on time factor in size control

While the main items of consideration in this article so far have been in reference to size control as affected by work conditions and machine characteristics, the fact should not be lost sight of that all operations, to be economically attractive, must be performed within a certain specific, or economic, time limit.

In the time allocated to one complete cycle of operation we have two elements, the actual machining time and the idle or preparatory and unloading time. The former is productive, and the latter unproductive. This latter item of unproductive or idle time has been attacked from many angles, particularly by the provision of automatic mechanisms which are not subject to the influence of fatigue and other psychological reactions which unfavorably affect the efforts of the human operator. Reference to Figure 6 will clearly indicate the different proportions of this element in the cycle of operations as performed by an operator, and as performed by an automatic machine.

If purely economic factors alone had to be considered, it is obvious that automatic machinery would give us the cheapest and most accurate results; however, this economic ideal is unattainable and always will be so. Hence, we must have a quite large proportion of manually operated machines.

The following remarks have to deal with considerations applying to non-automatic or manually operated machinery. Precision in size control within close limits is greatly affected by the degree of convenience of operation of the machine. The reasons for this are partly psychological and partly physical. The operator is affected psychologically by an atmosphere hard to define, but nevertheless very real, about every machine tool which is properly designed for close working. In other words, the machine looks right and carries the imprint of a designer thoroughly conversant with the problems of size control and determined to provide the operator with the maximum facilities for exercising this control under all conceivable operating conditions.

Physically the thing develops into a consideration of the fatigue factor, although it is a well known fact among executives experienced in the control of departments using machinery of this type that operators starting out with the handicap of unfavorable psychological reactions to a certain machine become easily tired and, therefore, careless and somewhat indifferent about the results which they produce as regards size control, this being regardless of the physical factor.

The points mentioned above will become more apparent if the manipulation facilities provided on, say, the modern jig-boring machine, are compared with the controls provided on, say, a standard center-type lathe of the vintage of ten years ago.

It becomes more obvious every year that people are responsive to fashion trends, and this influence does not exclude the machine tool industry. The style and contour of the modern automobile has made its influence felt far beyond the realms of the automobile designers' direct sphere of control.

We see the counterpart of their ideas on style in machine tools, refrigerators, and other items of common usage. Therefore, it behooves the designer of high class, highly productive, and highly accurate precision machinery, to create that atmosphere about his product which is conducive to accurate thinking and manipulation. This can be accomplished most adequately by the provision of the maximum convenience of control. Large, light hand wheels conveniently placed where they do not interfere; light, easily grasped levers, and the provision of a work-holding position which does not cause the operator to strain and stretch when he wants to take a look at the job. Micrometer dials should be large and clearly visible, vernier scales should be of large proportions, dial indicators should be of large size easily readable, and everything about the machine, including the painted surfaces, should be of that high degree of quality which will automatically make the operator think of quality measured in terms of size control and finish.

Reference to ease of control would not be complete without some mention being made of the provision of power-operated rapid traverse mechanisms. As time goes on, it becomes increasingly apparent that such mechanisms always pay dividends in the form of reduced operator fatigue and increased output with better quality of work.

Reliability of dead-stop mechanisms—The dictates of high production requirements have tended during recent years to bring the dead-stop mechanism method of sizing somewhat into disfavor, and the reason for this will be obvious if consideration is given to the following matters:

When traversing a unit of the machine, particularly a precision grinding machine up to a dead stop, the inference is that, when securing the size, all spring in the slides and operating mechanism will be gradually dissipated until the cutting element eventually clears itself of the work. This is obviously a lengthy procedure, and while undoubtedly the dying-out cut or, in other words, the sparking out of the grinding-wheel method of sizing, will continue to be used, it has ceased to be economically attrac-

tive where work must be produced in anything like mass production quantities.

Even with the increased use of hydraulic mechanisms, which lend themselves particularly well to dead-stop limitation of movement, there is a growing tendency, growing because of its economic attractiveness, not to permit the grinding wheel to spark out but, by controlling the pressure of contact between the wheel and the work, to secure uniformity of size within the prescribed limits. The saving in time is enormous. Consider, for example, the problem of sizing the diameter of the stem on an automobile poppet valve. Handling this job on the center-type grinder, where the cut must be allowed to spark out, production is something less than one valve per minute, whereas from 20 to 30 valves per minute can be produced on the centerless grinder with precisely the same dimensions and limits of accuracy on the work.

Gradual approach to size zero—No better example of lack of control over the sizing operation can be provided than in the operation of the older type of internal grinding machine not provided with automatic sizing facilities. With these machines, the operator frequently took more time to gage the work than he needed to actually grind it.

This condition was somewhat ameliorated by the provision of a stepped plug gage which indicated to the operator the amount of metal still to be removed from the bore. However, even the provision of this plug gage, which in itself was a great improvement over the "go" and "not go" type previously used, still consumed a disproportionate amount of time, and it was not until the introduction of the internal grinding machine with automatic sizing facilities that really high production methods became applicable to this class of grinding.

The three main types of automatic sizing mechanisms on the machines now on the market today all have their special merits, and it is significant that the latest to be released does not entail the use of a dead-stop mechanism. In this case, the cut is finished in the air, and by means of a light electrical contact alongside the grinding wheel a circuit is closed which withdraws the wheel from the work.

The introduction of hydraulics has provided the machine-tool manufacturer with a wonderfully sensitive means of controlling the approach to size zero, and the fullest advantage is being taken of this system where it is economically applicable.

Automatic compensation for the natural wear of the grinding wheel has long been a question confronting the designer of precision grinding equipment, but it was not until the introduction of automatic sizing equipment applied to a surface grinder, the automatic sizing facilities provided by the internal grinder manufacturers, and more recently, the provision of automatic compensation for wheel wear on cylindrical centerless grinders applied to through feed work, that this problem was really tackled. However, it now looks as though developments in this direction will continue to the point where wheel wear compensation will no longer be a serious obstacle in the way of complete automatic sizing within close tolerances.

It will be recollected that it was formerly necessary for the operator to check carefully the number of pieces he could grind before making compensation for the wheel wear, but even this procedure did not give him the necessary confidence to grind work without gaging every piece, and not infrequently this gaging time nearly equalled, and in some cases exceeded, the actual grinding portion of the work cycle.

In regular through feed centerless grinding operations it is usual to take from two to ten passes, depending on the degree of accuracy required, each pass removing its quota of metal and gradually decreasing the inconsistency in respect to uniformity of size of the piece being operated upon. In this way, the approach to the nominal size is gradual, and control of final size within very close tolerances is automatically assured. However, even with the light loads generated in final sizing under these conditions, due account must always be taken of the factor of grinding-wheel wear, though this problem also diminishes in importance as the amount of stock per pass is reduced.

Warning of approach of high or low limit—The main problem confronting the machine designer has been to produce a machine capable of sizing within close tolerances, the machine being operated by unskilled labor. In other words, it is frequently necessary for an operator with a very elementary knowledge of sizing to be called on to produce work with a total tolerance of two tenths of a thousandth. This condition has led to the introduction of many ingenious gages, some with audible, but most with dial-type mechanisms which automatically tell the operator when the high or low limit of the tolerance is being approached.

While gages of this type will, of course, check the work and tell the operator where his size errors are, this procedure only partially lightens the burden on the grinding-machine operator in securing size, and it was not until the introduction of the grinding-wheel wear-compensating mechanism that any automatic means was made available to the trade at large.

The inching-type compensator—The general acceptance of the theory that grinding wheels should be measured as regards efficiency by the amount of metal removed in a given time rather than by the length of time which the wheel would last has automatically led to the use of much softer bonded grinding wheels than had hitherto been the case, and while this factor materially increased the rate of metal-removal possibilities of most of the machines on the market, it also at the same time intensified the problem of grinding-wheel wear compensation.

In those cases where the quantities of work involved are so small that it would not pay to set up a machine for entirely automatic operation, a compromise has been effected which amounts to a push-button inching control over the sizing facilities on the machine. This type of equipment has many attractions, inasmuch as the operator when gaging the work, even at some point remote from the machine, can, by pressing a push button, inch in the control one ten-thousandth of an inch at a time and, therefore, quickly bring the throat of the machine back to the necessary dimension to insure that the work is produced within the prescribed limits of the tolerance.

The grinding machine as an inspection unit

In all manufacturing schemes where close sizing within fine tolerances is a necessity, the cost of adequate inspection prior to assembly is an important one, this cost ranking in importance with the other cost elements in proportion to the limits of the tolerance and the efficiency of the means provided the inspector for checking these limits.

It will be readily appreciated, therefore, that in those instances where the functions of the inspector and the operator taking care of the final grinding operation can be merged, there are some very real economies to be obtained and it is this thought which actuates the provision of the automatic compensation for wheel wear equipment now found on many precision grinding operations.

The makers of round bar stock also find that in many cases it is extremely attractive economically for them to pass their product between the wheels of a centerless grinding machine, thereby automatically controlling size, and at the same time removing scale and providing their inspectors with the wherewithal to readily detect seams and cracks which would otherwise only be brought to light in the customers' works. This procedure also, of course, takes care of the sizing of the bar within the limits prescribed by the trade practice. In other words, the grinding machine is made into an inspection unit.

Tool and gage accessories for grinding machines

Recognition of the fact that the dead-stop method of sizing leaves a lot to be desired from both the points of view of accuracy and speed, a number of gaging devices have been developed, the chief of which are the Pratt, the Arnold, and the Krupp. These devices are what might be termed indicating calipers, and as they are made in such a way that the calipering does not interfere with the actual grinding, the operator has in front of him a visible moving record of the size of the work, and as the amount of stock to be ground off diminishes, so the operator exercises a proportionate amount of caution as he approaches nominal size.

The use of this type of gage has effected some very striking economies in the costs of production on almost every class of work to which it has been applied, particularly in the automotive industry where tolerances are fine and the limit system is worked to consistently.

Recent developments with the calipering type gage indicate that the day is not far distant when the caliper mechanism will actually control the movements of the cutting tool, and one such installation is already in use. In this particular case, as the finger on the dial gage approaches the tolerance limits, an electrical contact is made which causes the grinding wheel head to recede, the actual control coming from the gage itself. It is safe to say that developments along these lines will still further reduce the cost of production, and particularly the cost of obtaining accurate size control under intensive manufacturing conditions.

Conclusions

Summing up the thoughts expressed in the previous paragraphs, it would seem, therefore, that cheap and accurate size control within close tolerance is dependent on the following factors:

1. The machine tool must be designed to insure consistency of operation under the widest range of conditions.
2. Limits for all machining operations must be specified with due regard to the cost of obtaining them.
3. The production department must exercise proper control over the quality of work in the operations preceding grinding.
4. The grinding machine must be placed in a position where it is not adversely affected by other equipment.
5. The machine must have the air of quality and reliability about it which will favorably affect the operator.

6. Fullest advantage must be taken of modern gaging facilities of all types suitable for the work being operated on, if lowest over-all costs are to be realized.
7. There must be a realization on the part of all concerned that cheap and accurate size control in a manufacturing program cannot be obtained under any circumstances with poorly designed equipment, and this proviso in the specification applies to the machine tools, the gaging equipment, the men who supervise, and the men who operate the scheme.

A.S.T.M. Book of Tentative Standards

The 1932 edition of the *Book of A.S.T.M. Tentative Standards* has been published by the American Society for Testing Materials.

The book includes all of the 226 specifications, test methods, definitions of terms, and recommended practices which have been tentatively approved by the A.S.T.M. and published for comment and criticism. Forty-seven of the total number of tentative standards published in this edition were accepted for publication for the first time in 1932.

The book includes tentative standards on ferrous metals; non-ferrous metals; cement, lime, gypsum, concrete, and clay products; preservative coatings; petroleum products and lubricants; road materials; coal, coke, timber, timber preservatives, shipping containers, waterproofing and roofing materials, slate and building stone; electrical insulating materials; rubber products; textile materials; and a few miscellaneous standards, under which are classified a facsimile of the viscosity-temperature chart for liquid petroleum products, new tentative methods of chemical analysis of calcium chloride, and the volume and specific gravity correction tables for creosote and coal tar.

In addition to the A.S.T.M. tentative standards, the book includes proposed revisions of standards which have been published for criticism.

Comment and criticism of the standards will be welcomed by the American Society for Testing Materials. All such communications should be addressed to the office of the Society, 1315 Spruce Street, Philadelphia.

Copies of the *Book of Tentative Standards* bound in blue cloth can be obtained from the American Society for Testing Materials at $8.00 per copy; in a heavy paper binding at $7.00 per copy. It may also be borrowed or purchased through the office of the American Standards Association.

Standardization of Design Proves Economical

The following editorial is reprinted from "American Machinist", March 3, 1932:

Inventive minds often oppose all forms of standardization as hindering progress. Inventors usually see chances for improvement after, or even before, each machine is completed, and want to embody the improvements in the next machine. While such a practice may be highly laudable from the theoretical point of view, every production manager knows what it does to costs. Nor is it solely a question of profit for the builder, it affects the user as well, and the slight improvement is often more than offset by the extra cost of replacements. The experience of an owner of a fleet of motor trucks gives both sides of the story.

Following the sometimes questionable practice of patronizing only local industries, he bought his trucks of a nearby builder, of the type who was constantly "improving" his product. As a result, every truck he bought was different in some particular from all the rest, and his cost for maintenance was abnormally high. The lack of standardization made it difficult to secure replacements without taking the worn or broken part to the factory for identification, and the time lost from the earning capacity of the trucks was no small item.

The experience resulted in his buying all new trucks from a builder who made but few changes in his designs, and these changes were so planned that replacements could be easily secured. Some of the main items in this truck had practically remained unchanged over a ten-year period, but the results, in day after day trucking, made the older design a more profitable investment.

In too many cases so-called improvements are simply opportunities for the inventor to display his ingenuity without appreciable economy in operation or maintenance. The cost of making the change and the added difficulty in replacement frequently works against the user as well as the maker. Real progress is always to be commended. But lower production costs which affect the price to the user frequently mean greater real economy than fancied improvements or constantly changing designs. We must strike a balance that will give the best results to all concerned.

ASA PROJECTS

A Review of Electrical Engineering Projects Under ASA Procedure

The third of a series of reviews of standardization projects under the procedure of the American Standards Association

The status of all electrical engineering projects under ASA procedure is summarized in the following review. The data presented are taken from the files of the American Standards Association and are corrected to December 1, 1932, bringing up to date the review of electrical projects published in the issue of January, 1932.

C1-1931—Regulations for Electric Wiring and Apparatus in Relation to Fire Hazard ("National Electrical Code")

Sponsor—National Fire Protection Association.

This code undergoes periodic revisions. The edition at present in force was approved as American Standard on August 18, 1931. Under the procedure of the committee having the code in charge, changes must be reported upon by the appropriate article committees before the full committee can consider them, unless this requirement is waived by unanimous consent of those attending a meeting of the full committee. It is expected that reports of most of the article committees will be distributed shortly, so that they may be studied prior to the meeting of the main committee soon after March 15, 1932. The plan initiated in 1930 to make tentative interim amendments to the code continues in effect. It is expected, however, that this procedure will be the subject of discussion at the forthcoming meeting of the committee.

C2-1927—National Electrical Safety Code

Sponsor—National Bureau of Standards.

This code was approved as American Standard in 1927. No revisions were made during the past year.

Rule 261 A 4(c) of the code provides that when new values for the ultimate fiber stresses of wood poles shall have been formulated by the Sectional Committee on Wood Poles (O5) the values given in tables 19, 20, and 21, paragraph 261 A 4(c) shall be proportionately adjusted. New values for these fiber stresses were approved as American Standard under date of November 28, 1930. Handbook 16 of the Bureau of Standards entitled *Wood Poles for Overhead Electric Lines* reprints rule 261 A 4(c) of the National Electrical Code and gives tables 19, 20, and 21 as revised by the new values of ultimate fiber stresses adopted by ASA.

C3—Electrical Fire and Safety Code

This proposed project, which was never formally initiated, was dropped from the books of ASA by the Standards Council at its meeting of November 30, 1932. This action was taken with the understanding that those interested in the subject would be free to bring it up again in the future.

C5-1929—Code for Protection against Lightning

Sponsors—American Institute of Electrical Engineers; National Bureau of Standards.

This code comprises five parts. Part I—Protection of Persons, Part II—Protection of Buildings and Miscellaneous Property, and Part III—Protection of Structures Containing Inflammable Liquids and Gases were approved by ASA in April, 1929. Parts I and II were approved as American Standards and Part III as American Tentative Standard. Parts IV and V—Protection of Electrical Circuits and Equipment against Lightning were printed by the Bureau of Standards as a preliminary report of the sectional committee, under the title of "Protection of Electrical Circuits and Equipment against Lightning," in September, 1929, for criticism and suggestions.

A revision of Parts I and II has been submitted by the sponsors for approval as American Standard. This proposal is now under consideration by the Electrical Standards Committee for its recommendation to the Standards Council on approval.

C6-1925—Terminal Markings for Electrical Apparatus

Sponsor—National Electrical Manufacturers Association.

No revision of this standard has been made dur-

ing the past year. The sponsor is compiling information looking to revision and it is expected that a meeting of the sectional committee will be held in the near future.

C8—Insulated Wires and Cables (Other than Telephone and Telegraph)

Sponsor—Electrical Standards Committee.

The following specifications have been approved as a result of this committee's work during the past year: Definitions and General Standards for Wires and Cables (C8a-1932); Specifications for Weatherproof (Weather Resisting) Wires and Cables (C8k1-1932); Specifications for Heat-Resisting Wires and Cables (C8k2-1932).

Another specification, covering impregnated paper insulation for lead-covered power cable, is now before ASA for approval. The transfer of sponsorship from the former ten sponsors to the ESC was accomplished with the unanimous approval of the ten organizations and will, it is expected, result in expediting the work. To date a revised personnel of the sectional committee has been approved, and a meeting will be held early in January to revise the committee's by-laws. The subcommittee structure will also be simplified and the scope of the work which is before each of the subcommittees will be reviewed.

C10-1924—Symbols for Electrical Equipment of Buildings

Sponsors—American Institute of Electrical Engineers; American Institute of Architects; Association of Electragists, International.

The Electrical Standards Committee is at present discussing with the sponsors for this project the possibility of including this work as a subdivision of the general project on Scientific and Engineering Symbols and Abbreviations (Z10).

C11-1927—Physical and Electrical Constants for Hard-Drawn Aluminum Conductors

Sponsor—American Institute of Electrical Engineers.

No revision of this standard has been made within the past year. The sectional committee which serves the U. S. National Committee of the International Electrotechnical Commission as advisor on the subject continues to be occupied with the international standardization of aluminum for conducting purposes.

C12-1928—Code for Electricity Meters

Sponsors—National Bureau of Standards; National Electric Light Association; Association of Edison Illuminating Companies.

This code was approved as an American Standard on February 20, 1928. The present is the third edition of the code, the second edition having been approved by ASA in 1922.

This code may be considered the fundamental authority on all matters relating to watthour meters and demand meters. It covers definitions, standards, specifications for the acceptance of types of watthour meters, and auxiliary apparatus for use with such meters, installation methods, test methods, laboratory and service tests for watthour meters, as well as similar information relative to demand meters.

The code has been used as a basis for proposals made through the United States National Committee of the International Electrotechnical Commission for international standardization of watthour meters.

C13-1926—Specifications for Tubular Steel Poles

Sponsor—American Transit Association.

The specifications were approved as American Tentative Standard on October 14, 1926.

The importance of this work is easily understood when it is considered that 1400 combinations of tubular steel poles have been shown in a catalog of a single company, while this specification lists 16 which are sufficient to meet practically all commercial needs. The specifications contain a simple table of deflections, together with the formula from which they are computed, for use in the selection of poles. The specifications apply to built-up tubular steel poles of three sections.

No revision of these specifications is contemplated at the present time.

C15-1923—600 Volt Direct-Current Overhead Trolley Construction

Sponsor—American Transit Association.

This standard was approved by ASA as American Tentative Standard on July 30, 1923. A revision of the existing standard is now under way.

C16—Radio

Sponsors—American Institute of Electrical Engineers; Institute of Radio Engineers.

Two standards, Vacuum Tube Base and Socket

Dimensions (C16c-1932) and Manufacturing Standards Applying to Broadcast Receivers (C16d-1932) were approved as American Standard during the year. In addition, the sectional committee has collaborated with the Sectional Committee on Definitions of Electrical Terms (C 42) in the preparation of a large group of definitions on the subject of radio communication in general. These are published in the report of the Sectional Committee on Definitions of Electrical Terms covered below.

Much of the work remaining before the sectional committee has to do with methods of test for radio broadcast receivers, radio transmitters, vacuum tubes, and allied apparatus. This standardization is necessarily slow on account of rapid developments in the art.

C17—Miscellaneous Pole Line Materials

Sponsor—ASA Electric Light and Power Group.

Work on this project has not yet been started.

C18-1930—Specifications for Dry Cells and Batteries

Sponsor—National Bureau of Standards.

The sectional committee is actively at work on a revision of these specifications. The personnel of the committee was reapproved during the year on account of changes which had taken place in the five years since its organization.

C19-1928—Industrial (Electrical) Control Apparatus

Sponsors—American Institute of Electrical Engineers; National Electrical Manufacturers Association.

Up to the present time no new developments have arisen which would indicate the necessity for a revision.

C22-1925—Instrument Transformers

Sponsor—Electrical Standards Committee.

No revision is at present contemplated but when the need for a revision arises it will be taken care of by the new Sectional Committee on Transformers (C57) covered below.

C28—Electric Motor Frame Dimensions

Sponsors—National Electrical Manufacturers Association; American Society of Mechanical Engineers.

The status of this project remains as reported in INDUSTRIAL STANDARDIZATION (formerly the ASA BULLETIN), January, 1932, page 39.

C29—Insulators for Electric Power Lines

Sponsor—Electrical Standards Committee.

The ESC has assumed sponsorship for this work following the assent of the former sponsors, the American Institute of Electrical Engineers and the National Electrical Manufacturers Association.

The standard on Insulator Tests (C29a-1930) continues to be satisfactory to industry and no revision is contemplated at the present time.

C33—Electrical Devices and Materials with Relation to Fire and Casualty Hazards

Sponsor—Underwriters' Laboratories.

The Electrical Standards Committee now has under discussion with the Underwriters' Laboratories, the proprietary sponsors for this project, the question of establishing a sectional committee.

C34—Mercury Arc Rectifiers

Sponsor—American Institute of Electrical Engineers.

In November, 1931, the sponsor submitted to ASA for approval as American Tentative Standard proposed standards for Metal Tank Mercury Arc Rectifiers. These proposed standards were referred to the Electrical Standards Committee for its recommendation on approval and in course of the consideration by the ESC certain objections were raised by the National Electrical Manufacturers Association. These objections were referred back to the sectional committee, which held a meeting in November, 1932, at which the objections were considered. A revised draft of the specifications, made in view of NEMA's objections, will be circulated to the sectional committee in the near future.

C35-1928—Railway Motors

Sponsor—American Institute of Electrical Engineers.

The personnel of this sectional committee has been approved and the committee is actively at work preparing the revision of A.I.E.E. Standard 11 on Railway Motors for submission to ASA for approval as American Standard.

C37—Power Switchgear

Sponsor—Electrical Standards Committee.

This project is a consolidation of the former projects on Oil Circuit Breakers and Disconnecting and Horn Gap Switches with the following scope: Oil

circuit breakers, large air circuit breakers, disconnecting and horn gap switches.

Sponsorship for the combined project was assumed by the Electrical Standards Committee following the assent of the two former sponsors, the American Institute of Electrical Engineers and the National Electrical Manufacturers Association.

The personnel of the committee has been approved and the committee is now in a position to engage actively in the work covered by its scope. The sectional committee also serves as the advisory group to the U. S. National Committee of the International Electrotechnical Commission on the subject of the rating of switches and circuit breakers.

C39—Electrical Measuring Instruments

Sponsor—Electrical Standards Committee.

Sponsorship for this project was assumed by the ESC following the assent of the two former sponsors, the American Institute of Electrical Engineers and the National Electrical Manufacturers Association. The following scope for the work has been approved and the sectional committee is now in the process of organization: Definitions, classification, rating, methods of test, and construction details for all types of electrical measuring instruments but not including: (1) watthour meters, (2) demand devices and their auxiliary apparatus, and (3) low precision or special instruments.

C40-1928—Storage Batteries

Sponsor—American Institute of Electrical Engineers.

No necessity for revision of this standard, which is under the proprietary sponsorship of the A.I.E.E., has been indicated to date.

C42—Definitions of Electrical Terms

Sponsor—American Institute of Electrical Engineers.

In August, 1932, this committee issued a draft report covering definitions of electrical terms. This report contains over 3400 definitions which, together with a comprehensive index, comprises a pamphlet of 208 pages.

It is interesting to note that this work required the formation of 17 subcommittees with a total personnel of about 120, and that additional expert help increased the number cooperating to over 300. The individual sections of the report were widely circulated in each stage of their development prior to publication. Differences of opinion on proper wording of individual definitions have thus been eliminated in a great many instances. The executive committee of the sectional committee was active in cases of overlapping of the jurisdiction of the various subcommittees. The committee is of the opinion, however, that even after its most earnest efforts to eliminate conflicting definitions, certain conflicts still exist. It was believed, however, that it was desirable to issue the report in its present form with the hope that still further suggestions of a helpful nature would be received which would lead to a solution of the questions still unsettled.

In collecting and compiling the definitions which served as the original basis of the committee's work, it soon became evident that there existed conflicting definitions of identical terms, all having the status of American Standards. In most such instances the sectional committee on electrical definitions has selected what appeared to it to be the most desirable wording. In other cases it has been felt desirable to suggest for a term or concept a wording differing from an accepted standard. The object in view always has been the development for each term of a wording expressing the meaning generally associated with it in electrical engineering in this country. When possible, definitions have been generalized so as not to preclude the different specific interpretations attached to particular applications.

Copies of the report may be obtained from the A.I.E.E. or from the office of the American Standards Association at the cost of $1.00 per copy.

C43—Overhead Trolley Line Material (*Proposed Project*)

The status of this project as given in Industrial Standardization (formerly the ASA Bulletin) January, 1932, page 41, has not been changed.

C44-1930—Rolled Threads for Screw Shells of Electric Sockets and Lamp Bases

Sponsors—American Society of Mechanical Engineers; National Electrical Manufacturers Association.

No change has been made during the year in this standard, which was approved in December, 1930. The sectional committee constitutes the group of advisors on lamp sockets and caps to the U. S. National Committee of the IEC.

C48-1931—Electric Railway Control Apparatus

Sponsor—American Institute of Electrical Engineers.

No revision of this standard, which was approved in December, 1931, is at present contemplated.

C50—Rotating Electrical Machinery

Sponsor—Electrical Standards Committee.

The ESC has assumed sponsorship for this work following the assent of the former sponsors, the American Institute of Electrical Engineers and the National Electrical Manufacturers Association.

The work of this sectional committee has reached an advanced stage, and draft standards covering the following types of rotating electrical machinery have been circulated to the sectional committee: direct-current rotating machines; alternators, synchronous motors and synchronous machines in general; synchronous converters; induction motors and induction machines in general; direct-current and alternating-current fractional horse power motors.

This committee, together with the new committee on transformers, described below, constitutes the group of advisors on rating of electrical machinery to the U. S. National Committee of the IEC.

C52—Electric Welding Apparatus

Sponsor—American Institute of Electrical Engineers; National Electrical Manufacturers Association.

The sectional committee has reviewed and revised the A.I.E.E. standards for electric arc welding apparatus and resistance welding apparatus. These proposed revisions have been circulated to the committee for final letter ballot and the vote is now almost complete. It is expected that the committee will therefore shortly be in a position to recommend to the sponsors the approval as American Standards of the two standards as revised.

C53—Recommendations for the Temperature Operation of Transformers

(*See C57*)

C54—Constant Current Transformers

(*See C57*)

C57—Transformers

Sponsor—Electrical Standards Committee.

This project is a consolidation of the following: Instrument Transformers (C22); Recommendation for the Temperature Operation of Transformers (C53); Constant Current Transformers (C54); and Transformers, Induction Regulators, and Reactors (C57), with the following scope: Formulation of standards for transformers (exclusive of auto transformers used as part of auto starters, automotive ignition transformers and communication transformers); voltage regulators of the induction or transformer type; and reactors.

The ESC is sponsor for the project and is proceeding with the organization of the sectional committee. The sectional committee when organized will, with the sectional committee on rotating electrical machinery (C50), constitute the advisory group on the rating of electrical machinery for the U. S. National Committee of the IEC.

C58—Shellac

Sponsor—American Society for Testing Materials.

The A.S.T.M. has accepted sponsorship for this project to cover shellac, synthetic resin, and other similar insulating materials. It was understood that the first phase of the work would cover methods of test for natural lacs only. The sectional committee, however, is not being organized, pending the outcome of consideration which is being given by the Electrical Standards Committee to the initiation of a project on specifications and methods of test for electrical insulating materials of which, of course, shellac would become one of the subdivisions. It now appears quite likely that the broad project on insulating materials will be started in the comparatively near future.

Electrical Standards Committee Acts on Projects

The Electrical Standards Committee, at its meeting on November 4, assumed sponsorship for the following projects which were formerly under the sponsorship of the American Institute of Electrical Engineers and the National Electrical Manufacturers Association:

Insulators for Electric Power Lines (C29)
Power Switchgear (C37)
Electrical Measuring Instruments (C39)
Rotating Electrical Machinery (C50)

The A.I.E.E. and the N.E.M.A. gave their consent to ESC sponsorship of these projects before the meeting of the ESC at which the action was taken.

The project on Power Switchgear (C37) is a consolidation of two former projects, Oil Circuit Breakers (C37) and Disconnecting and Horn Gap Switches (C38). The new project has the following scope:

Oil circuit breakers, large air circuit breakers, disconnecting and horn gap switches.

The ESC also approved the personnel which was

submitted by the A.I.E.E. and N.E.M.A. prior to the action by which ESC assumed sponsorship of this project. This sectional committee will serve as the advisory committee on this subject of the U. S. National Committee of the International Electrotechnical Commission.

The Electrical Standards Committee also approved a new scope for the project on Electrical Measuring Instruments (C39), and is proceeding with the organization of a sectional committee. The new scope is as follows:

> Definitions, classification, rating, methods of test, and construction details for all types of electrical measuring instruments but not including: (1) watthour meters, (2) demand devices and their auxiliary apparatus, and (3) low precision or special instruments.

A new project on Transformers (C57), which is a consolidation of the projects on Instrument Transformers (C22), Recommendation for the Temperature Operation of Transformers (C53), Constant Current Transformers (C54), and Transformers, Induction Regulators, and Reactors (C57), has been set up by the Electrical Standards Committee. The scope of the new project is as follows:

> Formulation of standards for transformers (exclusive of auto transformers used as part of auto starters, automotive ignition transformers and communication transformers); voltage regulators of the induction or transformer type; and reactors.

The ESC as sponsor for the project is proceeding with the organization of a sectional committee.

The Electrical Standards Committee also approved the personnel of the Sectional Committee on Railway Motors (C35), as submitted by the American Institute of Electrical Engineers, sponsor for the project, and the personnel of the Sectional Committee on Dry Cells and Batteries (C18) as submitted by the sponsor, the National Bureau of Standards.

The actions reported above represent the unanimous affirmative vote of the committee as required by the ESC constitution, and were reported to the ASA Standards Council on November 30.

Standards Council Acts on Electrical Projects

Upon the request of the Electrical Standards Committee, the ASA Standards Council in its meeting on November 30 designated the ESC to act as the ASA advisory group for the projects in the electrical engineering classification. This will include all the projects in the electrical engineering group with the exception of the project on Radio (C16), upon which a recommendation will be made later, and the following projects: Soft or Annealed Copper Wire (H4); Hard-Drawn Copper Wire (H14); Medium Hard-Drawn Copper Wire (H15); Tinned Soft or Annealed Copper Wire for Rubber Insulation (H16); Screw Threads for Rigid Electrical Conduits (B2a); Wood Poles (O5); Illuminating Engineering Nomenclature and Photometric Standards (Z7).

The Electrical Standards Committee was also designated to act in an advisory capacity jointly with other interested advisory or correlating committees on the project Scientific and Engineering Abbreviations (Z10). The ESC reported to the Standards Council that it did not wish to act as an advisory committee for the following projects: Electrical Equipment in Coal Mines (M2); Safety Code for Coal-Mine Transportation (M15); Electrical Equipment in Metal Mines (M24); Trolley, Storage Battery, and Combination Type Locomotives for Coal Mines (M25).

Upon recommendation of the Electrical Standards Committee, the Standards Council also took the following actions:

Electrical Fire and Safety Code (C3)—It was unanimously voted that this project be dropped from the list of projects under ASA procedure. This action was taken without prejudice to future action on the subject.

Insulated Wires and Cables (C8)—In order to clarify the records, the Standards Council confirmed the conditional assignment of this project to the sponsorship of the Electrical Standards Committee and approved the revised personnel of the sectional committee as recommended by the ESC.

Committee on Surface Qualities Holds Organization Meeting

A new sectional committee on classification and designation of surface qualities, organized under ASA procedure and jointly sponsored by the American Society of Mechanical Engineers and the Society of Automotive Engineers, held its organization meeting on December 9, 1932, in New York. After thorough discussion, the title of the project and the general scope of the work—Classification and Des-

ignation of Surfaces According to Quality of Surface—suggested by the special committee under the chairmanship of Major William B. Hardigg, which made a recommendation regarding the initiation of the project and sponsorship and scope to the Standards Council of the American Standards Association, was unanimously adopted by the sectional committee.

Lieutenant Colonel Charles A. Mettler, Ordnance Department, U. S. Army, New York, was elected temporary chairman, and H. G. Wills, Carborundum Company, Niagara Falls, New York, was elected temporary secretary of the sectional committee.

After considerable discussion as to what subjects should be taken up first and how the work on these subjects should be organized, the following subcommittees were appointed:

1. Standardization of surfaces produced by tools and abrasives.
2. Standardization of surfaces produced by mold, die, rolls, or any other means of deforming materials.
3. Standardization of coated surfaces.
4. Symbols for indicating surface quality on drawings.
5. Ways, means, and apparatus for measuring quality of surface.

New Standard on Spur Gear Tooth Form

A new American Standard on Spur Gear Tooth Form (B6.1-1932) has been approved by the American Standards Association. It is a combination of the data on the 14½-degree composite system and the 20-degree stub involute system approved by ASA in 1927 as American Tentative Standard B6b-1927 (now promoted to the status of American Standard) and new data referring to the 14½- and 20-degree full-depth involute systems.

The new standard was developed by Subcommittee 4, on Spur Gear Tooth Form, of the Sectional Committee on Standardization of Gears (B6). Henry J. Eberhardt, Newark Gear Cutting Machine Company, Newark, N. J., is chairman of the subcommittee, and Benjamin F. Waterman, Brown and Sharpe Manufacturing Company, Providence, R. I., is chairman of the sectional committee.

The committee, organized under ASA procedure, is jointly sponsored by the American Gear Manufacturers Association and the American Society of Mechanical Engineers.

Foreign Standards Available from ASA

New foreign standards available to Sustaining-Members for loan or purchase through the ASA office are listed below. They are available in the language of the country under which they are listed. In requesting copies of the standards it is necessary to list only the ASA serial numbers preceding the titles. Send either a post-card or a note containing only the name of the person wishing to receive the standards, and the numbers of the standards desired. The card or envelope should be addressed to the American Standards Association, 29 West 39th Street, New York.

Serial Number

Germany

313. Working voltages for heavy-current electrical installations, over 100 volts, electrical engineering

Great Britain

314. Bordeaux (terminal) connections for wire rope and chain for general engineering purposes
315. Bull-dog grips (clips) for wire ropes for general engineering purposes
316. Sockets for wire ropes for general engineering purposes
317. Quality of pitched or calibrated wrought-iron load chain for hand-operated pulley blocks
318. Thimbles for wire ropes for general engineering purposes
319. Cast-iron spigot and socket light rainwater pipes (cylindrical)
320. Electric overhead traveling cranes (power-driven in all motions)
321. Guide to aerodrome lighting
322. Identification colors for gas cylinders
323. Marking and coloring of foundry patterns
324. Solid rolled steel railway wheels and disc-wheel centers
325. Track-circuit insulation
326. Tungsten filament electric lamps

New Standard on Air Cylinders Published

The new American Standard, Rotating Air Cylinders and Adapters (B5.5-1932), approval of which by ASA was announced on page 296, November, 1932, has been published by the American Society of Mechanical Engineers, and is available at 35 cents per copy from the A.S.M.E. or the American Standards Association.

Standards for School Lighting

by

Henry B. Dates,[1] *Secretary*
Sectional Committee on Lighting
of School Buildings[2]

In 1918 the Illuminating Engineering Society prepared and issued a Code of Lighting School Buildings. Improvements in lighting practice made necessary a revision of this Code in 1924, at which time the Code was adopted as an American Standard under the procedure of the American Standards Association.

The last eight years have witnessed such a great advance in the knowledge of the science of seeing, and in lighting practice, that further revision has been necessary. The new standards of school lighting were therefore prepared under the joint sponsorship of the Illuminating Engineering Society and the American Institute of Architects and were adopted on September 15, 1932, as an American Standard under the procedure of the American Standards Association.

This 1932 edition of Standards of School Lighting is distinctly educational rather than mandatory in character. The subject matter is designed to present clearly and concisely to school authorities, architects, engineers, and regulatory bodies the desirable values of illuminating, and the lighting practices essential to the satisfactory performance of the visual tasks and activities demanded of pupils in our schools.

The work in our schools depends very largely upon seeing. Too low a value of illumination sacrifices safety, impairs vision, and so slows up the visual process as to retard the progress of the pupil and reduce the efficiency of the teacher. When through impaired vision students are deprived of the opportunity to acquire information that would be of use and value to them, or are compelled to spend additional months or years in school in order to repeat work in which they have failed, the individual, the community, and society in general suffer a heavy loss.

The human eye evolved over unknown ages in an outdoor environment demanding distant vision, and under the high values of illumination which prevail outdoors by day. Only very recently have we set the eye to close, visual tasks indoors and under lighting conditions in which the illumination is but a small fraction of that under which the eye developed. It is not strange, therefore, that defective vision is so prevalent.

To assure a better appreciation of the problems involved in the adequate lighting of schoolrooms, the first section of the Standards of School Lighting is devoted to a concise discussion of the important relations between lighting and vision. Investigations of our seeing processes emphasize more and more the general inadequacy of present-day indoor lighting for the visual tasks which are to be effected with speed, accuracy, and ease, and further definitely indicate that the progress of students in school is directly affected by the ease and facility with which their visual tasks are performed.

Seeing ability does not increase directly in proportion to the increase in the amount of light but at a much slower rate, and relatively large increases in the values of illumination are necessary to produce pronounced improvements in seeing ability. The Standards, therefore, proceed to a discussion of what constitutes good lighting and how good lighting can be secured with both natural and artificial lighting.

In the recommended values of illumination for school interiors, it should be noted that schoolrooms are grouped into four classes according to the severity of the visual tasks demanded.

A range rather than a single foot-candle value is given for each classification in order to take into account the proportion of time under which the room is used under artificial lighting, which varies with latitude, prevailing sky brightness, and interference from other buildings and trees. Some parts of the country enjoy bright skies most of the time, whereas in others dark skies prevail and daylight wanes early through a considerable part of the school year. Again, some schools are used a great deal for night classes; in others, all pupils are dismissed early in the day. The lower values should therefore be taken as applying to the exceptionally favorable conditions; more often it will be found desirable to make provision for values in the upper portion of

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[2] (A23-1932); H. H. Magsdick, General Electric Company, Cleveland, Ohio, is chairman of the committee; the Illuminating Engineering Society and the American Institute of Architects are sponsors for the project.

the range; in fact, in many instances it will be well to exceed them.

Glare a common fault

The presence of glare is one of the most common and serious faults of lighting.

Glare is objectionable because it interferes with clear vision and increases the risk of accident; it causes discomfort and eye fatigue and results in errors, thus reducing the efficiency of the student; and, if long-continued, it may result in impairment of vision.

Glare may be caused by too much light directed toward the eye, a light source of excessive brightness, or too great a contrast between the light source and surrounding surfaces. To avoid harmful results the brightness of lighting units should not exceed the recommended limits.

The use of unglazed paper and dull or mat finishes for desk tops, blackboards, furniture, walls, and ceilings eliminates reflected glare and promotes better seeing and visual comfort.

For natural lighting, window shades are an essential part of the equipment of a schoolroom. Their real purpose is to intercept the direct sunlight and diffuse it throughout the room, to eliminate exterior glare, and to control the relative illumination at different points within the room. Translucent shades should be used to control and diffuse daylight. An additional shade, opaque and dark in color, should be installed to darken rooms when a projector is used. From the widespread use of only opaque window shades it would seem that the popular idea is that the shade should exclude daylight from the room rather than to control and diffuse it. Valuable suggestions on the selection and installation of window shades will be found in this section.

In planning for artificial lighting, it is not sufficient, in order to meet the specifications for good lighting, merely to select and install a proper number of suitable lighting units, but it is also essential to have adequate wiring capacity, so that, with properly designed lighting equipment, the lamps themselves may operate efficiently.

Once a modern fireproof building is completed, the cost of rewiring is very high but the cost of providing sufficient capacity in the original plans is very small. As an aid to architects and engineers in planning, not only for the present but for the future requirements, a section has been incorporated discussing this question of wiring with respect to lighting and recommending the capacity that should be provided for in the wiring for various classes of rooms. A five per cent drop in voltage at the lamp results in fifteen per cent reduction in the light output. Surveys show that the voltage drops in existing school buildings, especially those that have been built for some time, are such as to preclude improvements in lighting without excessive cost in rewiring. The importance of this subject in the planning of wiring of new buildings cannot be over-estimated.

Considerable emphasis has been placed upon maintenance. The proper and adequate maintenance of equipment for both natural and artificial lighting is essential. Illumination which may be adequate when the system is installed will soon deteriorate unless the system is properly maintained. Walls and ceilings darkened by smoke and dust, dirty windows and shades, grimy lighting reflectors and enclosing globes, lamps of the wrong size or of too high voltage rating, and overloaded wiring will render the lighting system ineffectual however carefully designed.

The decrease in illumination due to these causes is often so gradual that it is not noticed. Inasmuch as the values of artificial illumination in general use border so closely on the inadequate, any considerable decrease in illumination is certain to interfere seriously with vision.

Higher illumination values needed

Better knowledge of the relation of lighting to vision and of the economic value of conserving the eyesight of children having normal vision and helping those with defective vision, and the inclusion in the curriculum of more subjects requiring close application to detail, point to the use of higher values of illumination than those now generally provided.

The underlying thought in the preparation of the Standards has been to present the factors in lighting that are essential to secure safe and adequate lighting in our schools and to indicate the principles on which good lighting, both from natural and artificial sources, depends.

The final section of the Standards is intended as an aid to state authorities in setting up mandatory requirements for the protection of the occupants of school buildings from accidents or impairment of sight.

For clarity of treatment and convenience of reference the Standards of School Lighting have been divided into the following five sections: Lighting and vision; What constitutes good lighting; The natural lighting of schoolrooms; The artificial lighting of schoolrooms; Suggested regulations to be established for regulatory bodies.

Tables and charts, together with many photographs of actual good lighting installations in schools, are included to illustrate and amplify the discussions.

Abbreviations for Scientific and Engineering Terms

An extensive abstract of the American Tentative Standard for Abbreviations for Scientific and Engineering Terms (Z10i-1932) is published below. Because of the confusing variations in the use of abbreviations by different writers and in different publications, and also because of the wide interest in the subject, this abstract is being made available to readers of INDUSTRIAL STANDARDIZATION. The complete standard has been published by the American Society of Mechanical Engineers and may be purchased at 40 cents per copy either from the Society or from the American Standards Association.

The standard was prepared by a subcommittee, under the chairmanship of George A. Stetson, of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations (Z10). Sponsors for the committee are the American Association for the Advancement of Science, the American Institute of Electrical Engineers, the American Society of Civil Engineers, the Society for the Promotion of Engineering Education, and the American Society of Mechanical Engineers.

The subcommittee which prepared the standard was organized early in 1927. It has prepared eight revisions of its first report, which was issued in July, 1927. In the present standard, advantage was taken of the widespread comment and suggestion which resulted from the publication of the revisions.

The abstract of the standard follows:

Fundamental Rules

Abbreviations should be used sparingly in text and with regard to the context and to the training of the reader. Terms denoting units of measurement should be abbreviated in the text only when preceded by the amounts indicated in numerals; thus "several inches," "one inch," "12 in." In tabular matter, specifications, maps, drawings, and texts for special purposes, the use of abbreviations should be governed only by the desirability of conserving space.

A sentence should not begin with a numeral followed by an abbreviation.

Short words such as ton, day, and mile should be spelled out.

Abbreviations should not be used where the meaning will not be clear. In case of doubt, spell out.

The use of conventional signs for abbreviations in text is not recommended; thus "per," not / ; "lb," not #; "in.," not ″. Such signs may be used sparingly in tables and similar places for conserving space.

The Committee endorses the movement which was begun by the International Committee on Weights and Measures in omitting the period in abbreviations of metric units and further endorses the growing tendency toward the omission in abbreviations of other origin. In the interests of economy and the reduction of waste the elimination of the period is recommended except where such an omission results in an English word. Exceptions to this practice will be found in a few mathematical and chemical terms, such as sin, tan, log, As, etc.

The letters of such abbreviations as A.S.M.E. should not be spaced (not A. S. M. E.).

The use in text of exponents for the abbreviations of square and cube and of the negative exponents for terms involving "per" is not recommended. The superior figures are usually not available on the keyboards of typesetting and linotype machines and composition is therefore delayed. There is also the likelihood of confusion with footnote reference numbers. These shorter forms are permissible in tables and are sometimes difficult to avoid in text.

Abbreviations

In this initial list of Abbreviations for Scientific and Engineering Terms only those most commonly used have been included. These forms are recommended for readers whose familiarity with the terms used makes possible a maximum of abbreviations. For other classes of readers editors may wish to use less contracted combinations made up from this list. For example, the list gives the abbreviation of the term "feet per second" as "fps." To some readers ft per sec will be more easily understood.

Absolute	abs
Acre	acre
Acre-foot	acre-ft
Air horsepower	air hp
Alternating-current (as adjective)	a-c
Ampere	amp
Ampere-hour	amp-hr
Angstrom unit	A
Antilogarithm	antilog
Atomic weight	at. wt
Atmosphere	atm

Average	avg
Avoirdupois	avdp
Barometer	bar.
Baumé	Bé
Board feet (feet board measure)	fbm
Boiler pressure	bp
Boiling point	bp
Brake horsepower	bhp
Brake horsepower-hour	bhp-hr
Brinell hardness number	Bhn
British thermal unit	Btu or B†
Calory	cal
Candle	c
Candlepower	cp
Center to center	c to c
Centigram	cg
Centiliter	cl
Centimeter	cm
Centimeter-gram-second (system)	cgs
Cent	c or ¢
Chemical	chem
Chemically pure	cp
Circular	cir
Circular mils	cir mils
Coefficient	coef
Cologarithm	colog
Conductivity	cond
Constant	const
Cosecant	csc
Cosine	cos
Cotangent	ctn
Coulomb	spell out
Counter electromotive force	counter emf
Cubic	cu
Cubic centimeter	cu cm, cm^3, cc (liquid, meaning milliliter, ml)
Cubic foot	cu ft
Cubic feet per second	cfs
Cubic inch	cu in.
Cubic meter	cu m or m^3
Cubic micron	cu μ or cu mu or μ^3
Cubic millimeter	cu mm or mm^3
Cubic yard	cu yd
Current density	spell out
Cylinder	cyl
Day	spell out
Decibel	db
Degree	deg or °
Degree Centigrade	C
Degree Fahrenheit	F
Degree Kelvin	K
Degree Réaumur	R
Diameter	diam
Direct-current (as adjective)	d-c
Dozen	doz
Dram	dr
Efficiency	eff
Electric	elec
Electromotive force	emf
Elevation	el
Engine	eng
Engineer	engr
Engineering	engg
Equation	eq
External	ext
Farad	spell out
Feet board measure (board feet)	fbm
Feet per minute	fpm
Feet per second	fps
Fluid	fl
Foot	ft
Foot-candle	ft-c
Foot-Lambert	ft-L
Foot-pound	ft-lb
Foot-pound-second (system)	fps
Freezing point	fp
Frequency	spell out
Fusion point	fnp
Gallon	gal
Gallons per minute	gpm
Gallons per second	gps
Grain	spell out
Gram	g
Gram-calory	g-cal
Greatest common divisor	gcd
Hectare	ha
Henry	h
High-pressure (adjective)	h-p
Horsepower	hp
Horsepower-hour	hp-hr
Hour	hr
Hundred	C
Inch	in.
Inch-pound	in-lb
Inches per second	ips
Indicated horsepower	ihp
Indicated horsepower-hour	ihp-hr
Intermediate-pressure (adjective)	i-p
Internal	int
Joule	j
Kilocycle	kc

Kilogram	kg
Kilogram-meter	kg-m
Kilograms per cubic meter or kg/m^3	kg per cu m
Kilograms per second	kgps
Kiloliter	kl
Kilometer	km
Kilometers per second	kmps
Kilovar (reactive kilovolt-ampere)	kvar
Kilovarhour (reactive kilovolt-ampere-hour)	kvarh
Kilovolt	kv
Kilovolt-ampere	kva
Kilowatt	kw
Kilowatthour	kwhr
Lambert	L
Latitude	lat
Least common multiple	lcm
Linear foot	lin ft
Liter	l
Liquid	liq
Logarithm (common)	log
Logarithm (natural)	$\log_e$ or ln
Longitude	long.
Low-pressure (as adjective)	l-p
Lumen	l
Lumen-hour	l-hr
Lumens per watt	lpw
Magnetomotive force	mmf
Mass	spell out
Maximum	max
Mean effective pressure	mep
Mean horizontal candlepower	mhcp
Megohm	spell out
Melting point	mp
Meter	m
Meter-kilogram	m-kg
Mho	spell out
Microampere	μa or mu a
Microfarad	μf or mu f
Micromicron	$\mu\mu$ or mu mu
Micron	μ mu
Microwatt	μw or mu w
Mile	spell out
Miles per hour	mph
Miles per hour per second	mphps
Milliampere	ma
Millifarad	mf
Milligram	mg
Millihenry	mh
Millilambert	mL
Milliliter	ml
Millimeter	mm
Millimicron	mμ or m mu

Million	spell out
Million gallons per day	mgd
Millivolt	mv
Minimum	min
Minute	min
Minute (angular measure)	′
Molecular weight	mol. wt
Mol	spell out
Month	spell out
National Electrical Code	NEC
Ohm	spell out
Ohm-centimeter	ohm-cm
Ounce	oz
Ounce-foot	oz-ft
Ounce-inch	oz-in.
Parts per million	ppm
Pennyweight	dwt
Pint	pt
Pound	lb
Pound-foot	lb-ft
Pound-inch	lb-in.
Pounds per brake horsepower-hour	lb per bhp-hr
Pounds per square foot	lb per sq ft
Pounds per square inch	lb per sq in.
Power factor	spell out
Quart	qt
Radian	spell out
Reactive kilovolt-ampere	rkva
Reactive volt-ampere	rva
Revolutions per minute	rpm
Revolutions per second	rps
Rod	spell out
Root mean square	rms
Round	rd
Secant	sec
Second	sec
Second (angular measure)	″
Second-foot (see cubic feet per second)	
Shaft horsepower	shp
Shilling	s
Sine	sin
Specific gravity	sp gr
Specific heat	sp ht
Spherical candle power	scp
Square	sq
Square centimeter	sq cm or cm^2
Square foot	sq ft
Square inch	sq in.
Square kilometer	sq km or km^2

Square meter	sq m or m^2
Square micron	sq μ or sq mu or μ^2
Square millimeter	sq mm or mm^2
Square root of mean square	rms
Standard	std
Tangent	tan
Temperature	temp
Tensile strength	ts
Thousand	M
Ton	spell out
Ton-mile	spell out
Var (reactive volt-ampere)	var
Volt	v
Volt-ampere	va
Volt-coulomb	spell out
Watt	w
Watthour	whr
Watts per candle	wpc
Week	spell out
Weight	wt
Yard	yd
Year	yr

Revised Standard on Steel Fittings and Flanges

The new American Standard, Steel Flanged Fittings and Companion Flanges (B16e-1932), recently approved by the American Standards Association, is a revision of the American Tentative Standard B16e-1927. In the revision, the pressure ratings of 250 and 1350 lb per sq in. have been increased to 300 and 1500 lb per sq in. respectively. The standard now covers the same flanged fittings as the old standard, and in addition to these, fittings for a maximum steam service pressure of 150 lb per in. at 500 F (or 100 lb per sq in. at 750 F), and flanged base-fittings for pressures of 300, 400, 600, and 900 lb per in. Companion flanges are given for the pressure ratings of 150, 300, 400, 600, 900, and 1500 lb per sq in. The 3½-inch flanged fittings in the 900 and 1500 lb series have been eliminated. The revision of the old standard has resulted in changes of certain dimensions, such as the minimum metal thickness of some fittings, which was increased on account of the increase in two pressure ratings.

The revised standard was developed by Subcommittee 3 on Steel Flanges and Flanged Fittings, of the Sectional Committee on Pipe Flanges and Fittings (B16). The chairman of the sectional committee, and also of subcommittee 3, is Collins P. Bliss, Dean, Engineering School, New York University. The work on this project is jointly sponsored by the American Society of Mechanical Engineers, the Manufacturers Standardization Society of the Valve and Fittings Industry, and the Heating and Piping Contractors National Association.

Copies of the new standard are available from the ASA office at 65 cents each.

Uniformity Needed in Water Heater Specifications

The following editorial is reprinted from the "Electrical World" for June 25, 1932:

Water-heater specifications show what a chaotic condition exists in this branch of the industry. The number of possibilities of combinations of heater sizes and wattages and controls is almost infinite, almost as great in variety as the combinations obtainable out of a deck of ordinary playing cards. There are large tanks with small heaters, small tanks with large heaters, controls of time and temperature and off-peak almost without limit in variety of design. Some want one element, some two, some three. Some want temperature control on one, two, or all; some want temperature control on none, just off-peak time control. Some want two tanks; some, one tank with a division in it. The normal procedure has been for each utility in turn to delegate an engineer to make a survey of the water-heater situation. The survey has taken from one year to three years to make. The engineer has had free rein to make his tests and arrive at his conclusions. His report is based on these tests and his recommendations are final. Didn't he make a careful investigation? Could he be wrong? Of course not. It took him and his assistants two years to arrive at this conclusion. They had the able assistance of Mr. So-and-So of the Blank Company, which has had wide experience in water heating. The report must be right.

Surely there cannot be such a discrepancy in generating and distributing methods in the United States as absolutely to necessitate more than three hundred separate and distinct types or combinations of water heaters, including controlling mechanisms and methods of application. Surely some standards of tank size or control can be arrived at which will enable manufacturers to make a heater that will answer at least 60 or 70 per cent of the needs.